ISSN-0706-1034

Dominant Firm Price Leadership

An Empirical Examination

Mineral Policy Background Paper No: 23

Ontario Ministry of Northern Development and Mines

Mines and Minerals Division

87-02099/

THE AUTHORS

Hae-Shin Hwang, Ph.D.
Professor, Department of Economics
Texas A&M University

Charles W. Smithson, Ph.D.
Professor, Department of Economics
Texas A&M University

NOTE:

This background paper does not represent official policy and the views expressed herein are not necessarily the viewpoint of the Government of Ontario.

November 1986

Price: $10.00

Dominant Firm Price Leadership

An Empirical Examination

Hae-Shin Hwang
Charles W. Smithson

Department of Economics

Texas A&M University

November, 1986

DOMINANT FIRM PRICE LEADERSHIP: AN EMPIRICAL EXAMINATION

Hae Shin Hwang and Charles W. Smithson*

A topic included by many intermediate microeconomics texts and virtually all texts in industrial organization is dominant firm price leadership. The fact that this theoretical paradigm has been so widely discussed implies that the theory is well established: Inclusion of this paradigm at the textbook level implies that the behavior of a market with one large producer and a number of small producers is well known, well documented, and entirely predictable. However, this in not the case. In our survey of the economics literature we found not one instance in which the behavior resulting from a market characterized by dominant firm price leadership had been subjected to empirical verification.[1] Hence, dominant firm price leadership appears to be a theoretical paradigm in search of an application.

Contrarily, market experts suggested that the world nickel market was characterized by dominant firm price leadership, at least until the mid 1970s. As observers of this market noted, one producer -- Inco Ltd. -- was so large relative to the market that it could set price so as to maximize its own profit, while the other, smaller firms had to accept the price set by Inco in the same way that competitive firms accept the market price. Indeed, in the December 9, 1985 issue of The New York Times, Douglas Martin provided a commonly held view of the nickel market when he referred to Inco "...setting the price almost as a matter of divine right." The physical characteristics of the market did fit those for dominant firm price leadership to occur. However, we know of no empirical analysis demonstrating that the nickel market was actually characterized by dominant

firm price leadership. (Carefully placing tongue in cheek, we might say that the nickel market was an application in search of a theory which would accurately organize the data.)

Hence, we found ourselves faced with an exceptional research opportunity: On one side, the theory of dominant firm price leadership has been widely described theoretically but has never been subjected to an empirical test. On the other, the widely held belief that the nickel market has been characterized by dominant firm price leadership has also never been tested empirically. The obvious approach was to apply the model of dominant firm price leadership to data for the nickel market to determine if the behavior predicated theoretically could be confirmed empirically. And that is precisely what we did and what we report in this paper. In the first section, we provide a description of the paradigm of dominant firm price leadership as is commonly presented in economics textbooks. We next provide a cursory overview of the nickel market to indicate how the perception arose that this market was characterized by dominant firm price leadership. Given these theoretical and institutional structures, we then describe our empirical models and the results of our estimations. We conclude this paper with a brief recapitulation.

Dominant Firm Price Leadership -- The Textbook Paradigm

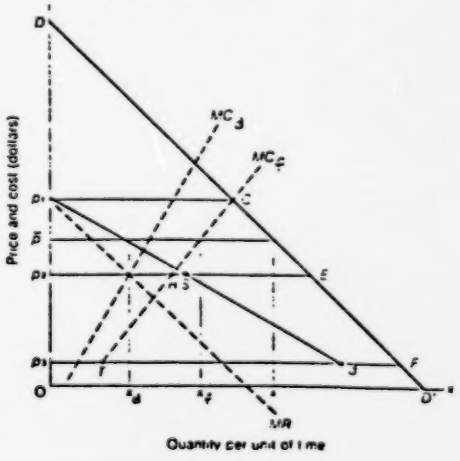
In the various texts that describe this market structure, dominant firm price leadership is proposed as a paradigm that will organize the behavior of the participants in markets in which there is one large firm and a number of smaller firms. The large firm is dominant in the sense that its output is large enough to permit it to unilaterally determine price. Hence the

dominant firm is able to set price and to enforce the price it sets via its output decision. The smaller firms -- the competitive fringe -- are each sufficiently small to behave as would firms in a perfectly competitive market: they accept the market price as given.

The theoretical behavior of the participants in such a market is simple. For any price set by a dominant firm, the competitive fringe will maximize their profits by producing that output at which their own marginal costs are equal to price. Knowing this, the dominant firm realizes that, for every price it sets, the competitive fringe firms will supply a predictable amount to the market, leaving some "residual demand" for the dominant firm. It is this residual demand that is of the most importance to the dominant firm, since the dominant firm is essentially a monopolist for this residual demand. Hence, the dominant firm will set the price so as to maximize its own profit for its "residual market".

The following figure is the traditional analytic device used to explain firm behavior under dominant firm price leadership. The line DD' is the market demand curve, MC_d is the marginal cost curve for the dominant firm, and MC_f is the aggregated marginal cost curve for all of the firms in the competitive fringe.

Price leadership by the dominant firm



Source: S. Charles Maurice and Charles W. Smithson Managerial Economics (First Edition) Homewood, Illinois: Richard D. Irwin, 1981, page 381.

Were the dominant firm to set price at p_1, the competitive fringe would equate marginal cost with this price and would supply an amount equal to p_1C, which is precisely total market demand. Hence, for a price of p_1 (or higher) the competitive fringe would supply all the market demand and the dominant firm's residual demand would be zero. However, if the dominant firm set price equal to p_2, the competitive fringe would supply an amount equal to p_2R (by $p_2 = MC_f$) and, since the market would demand the amount p_2E, the residual demand is $p_2E - p_2R = RE$. Moving RE leftward to the axis, the dominant firm's residual demand at price p_2 is p_2S. Likewise, for price p_3, the competitive fringe would supply p_3T, leaving $p_3F - p_3T = TF = p_3d$ for the dominant firm. And, for prices below p_3, the competitive fringe would supply no output; so, the dominant firm's residual demand is the market demand. Therefore, the residual demand curve -- the demand curve available only to the dominant firm -- is p_1d FD'.

Given this residual demand, the dominant firm behaves as if it were a monopolist in its isolated market: The marginal revenue curve associated with demand curve p_1d is illustrated as MR. The dominant firm equates its marginal cost (MC_d) with this marginal revenue, with the result that the profit-maximizing output is X_d. From its residual demand curve, the price corresponding to an output of X_d (for the dominant firm) is $\bar{p}$. Hence, to maximize its own profit, the dominant firm will set a price $\bar{p}$ and supply X_d. At price $\bar{p}$, the competitive fringe will equate MC_f with $\bar{p}$ and will supply X_f. And, because of the way the residual demand curve was constructed, the sum of X_d and X_f will be equal to total market demand at price $\bar{p}$.

The preceding graphical analysis indicates that the output forthcoming from the competitive fringe (and, therefore, from any of the competitive

fringe firms) is determined completely by the market price and its own marginal cost function. Hence, the output function for the competitive fringe could be written as

$$q^f = f\ (p,\ C^f) \tag{1}$$

However, output determination for the dominant firm is more complicated. For the dominant firm, the optimal output level is that at which its marginal cost is equal to the marginal revenue associated with the residual demand curve. The graphical analysis indicates that the residual demand curve is simply total demand (D) minus the amount supplied by the fringe firms (q^f). Hence, the implication of the textbook description of dominant firm price leadership is that the dominant firm's output decision is determined by the function

$$q^d = f[(D - q^f),\ C^d] \tag{2}$$

Looking at equations (1) and (2), the empirical methodology of this paper is apparent: the received paradigm of dominant firm price leadership indicates that the fringe firms will base their output decision on a different set of variables than will the dominant firm and that this difference should be observable empirically. Implicitly combining equations (1) and (2) and generalizing to an unspecified ith firm, the output function is

$$q^i = f(p,\ D,\ \sum^{j \neq i} q^j,\ C^i), \tag{3}$$

where $\sum_{j \neq i} q^j$ is the output of all firms other than firm i. Using a linear form for equation (3), we could form the estimation equation

$$q^i = \alpha_0 + \alpha_1 p + \alpha_2 D + \alpha_3 \left(\sum_{j \neq i} q^j\right) + \alpha_4 C^i \qquad (4)$$

The traditional view of dominant firm price leadership implies different sign patterns for the parameters, depending on whether or not firm i is the dominant firm:

Parameter	Dominant Firm	Competitive Fringe Firm
α_1	0	+
α_2	+	0
α_3	-	0
α_4	-	-

As is evident in the preceding, the dominant firm price leadership paradigm implies that the firms in the competitive fringe react to price, while the dominant firm reacts to shift in the residual demand curve. And, if such a market exists, this difference in behavior should be observable empirically.

Dominant Firm Price Leadership -- Evolution of the Nickel Market

As noted in the introduction, the prevailing view of the nickel market in its hey day was of a market dominated by a single large firm, with that firm having price setting power. To understand how this view arose, it is necessary to trace the evolution of the world nickel market. Our brief description of this evolution is based on the work of W. Charles Maurice and Philip J. Mizzi in An Analysis of Market Structure: The Nickel Industry.[2]

Readers interested in a more complete description of this evolution and in locating other descriptions of the market are referred to that source.

Although not identified as a separate element until the mid-eighteenth century, nickel had actually been used as a hardener for centuries: Nickel alloys exist in copper and bronze artifacts dated as early as 3500 B.C.; and, the luck attributed to swords made from meteoric metal in the 17th century may have been less the result of the metal falling from heaven than from the nickel content of the metal.

The earliest source of intentionally mixed nickel was New Caledonia. Nickel deposits were identified in the 1860s and by the 1880s significant production existed. However, the growth of nickel production from New Caledonia was hampered by a shortage of labor and smelting facilities and by the distance between New Caledonia and the markets in Europe.

Also in the 1880s, nickel deposits in Canada began to be exploited. At first, nickel was extracted as a byproduct of copper extraction, since the sulphide ore was difficult to refine. However, the advent of new refining processes by the Mond Nickel Company and the Orford Copper Company led to growth of Canadian production.

At the turn of the century, there were only two significant producing areas for nickel. New Caledonia accounted for two-thirds of total world production; the remainder came chiefly from Canada.

In 1902, the International Nickel Company -- later to be known as Inco -- was founded by the merger of the Orford Copper Company with a mining firm in Sudbury, Ontario. And, in 1929, Inco acquired the Mond Nickel Company. Inco's growth had begun. By 1934, Canada -- Inco -- was the largest producer of nickel, accounting for 81 percent of world production.

And, Inco's dominance of the nickel market (in terms of market share, if nothing else) would continue for decades. Until 1950, Canada's share of world production remained in excess of 80 percent and that production came primarily from Inco, with some production from Falconbridge Nickel Mines Limited which had been formed in 1929. Over the period 1930-1950, the growth in demand -- reaching its peak during World War II -- was met primarily from Canadian production. In contrast to the set of circumstances that blocked growth from the deposits in New Caledonia, the size and quality of the Sudbury Basin deposits, in conjunction with their locational advantage, gave Canada and Inco a dominant position in the market.

However, new competitors were attracted. In 1950, only five countries produced nickel; and, of these, Canada dominated production with 76%, with most of the remaining production from the Soviet Union. In 1950, a new competitor for Inco within Canada appeared as Sherritt Gordon Mines began operation in Manitoba. By 1957, five additional countries were producing nickel; but, Canada continued to dominate, holding almost 60% of the market.

Throughout the 1960s, Inco maintained virtual control over the nickel market and the world price of nickel. Canada continued to supply the majority of the world's nickel and, since most of the Soviet Union's production was for its own domestic use, Canada truly dominated market-traded nickel. However, dominance was not to be Inco's forever. In the 1960's plans were being made to renovate the facilities in New Caledonia. The Soviet Union continued to expand capacity at home and in Cuba, and development activities were ongoing in Australia and the Philippines.

In the 1970s, the dominance Inco has enjoyed for some four decades was lost. On one side, the entry of new firms and the expansion of existing firms

had made more nickel available. On the other, the growth rate in the world demand for nickel began to decline. Increasing production capacity, without a corresponding increase in demand, meant that Inco's position would be eroded. In 1968, Canada's market share had first fallen below 50%, by 1982, Canada's share was 23%.

While still the largest producer in the world market with its 23% share of the market, Canada no longer held the dominant position. The second largest producer -- the Soviet Union -- had an almost identical share (22.5%) and Australia and New Caledonia each accounted for 10%. With the loss of market share had gone price setting power. Faced with continuing challenges from Falconbridge, Inco had discontinued publishing price in 1977.

Empirical Analyses

To this point, we have argued that the paradigm of dominant firm price leadership can be examined empirically and that the nickel market is perceived to have been characterized by dominant firm price leadership until the mid 1970s. These two arguments point to a straightforward plan of action: Collect data from all the firms in the nickel market and estimate equation (4) for each firm to determine if the dominant firm -- Inco-- displayed the predicted differences from the other firms. However, as is so often the case, implementation of the straightforward plan was blocked.

The first problem was a common one -- data availability. Data were simply not available by individual firm. However, we did have a reliable set of data by country group, which we had used previously developing an econometric forecasting model.[3] The question became whether a data set

aggregated to seven county groups -- North America, South America, Asia, Africa, Europe, Oceania, and Centrally Planned -- would be acceptable for the econometric analysis of a firm-level behavioral question. In the case of the competitive fringe, the aggregation presented no serious conceptual problem; since South America, Asia, Africa, Europe, Oceania, and the centrally planned economies contain only firms that would be characterized as competitive fringe, each of the country groups could be regarded as a competitive fringe "firm". It is, however, in treating North America as the dominant "firm" that conceptual difficulty is encountered. While North America contains the purported dominant firm, it also contains several firms that would be characterized as part of the competitive fringe. The degree to which the inclusion of the competitive fringe firm data in the data for the dominant "firm" -- the North America data -- will impact on the empirical results depends on the size of the competitive fringe output relative to Inco's output and the degree to which nickel output in North America moves proportionately with Inco's output. The larger is Inco's output relative to total North America output or the more closely changes in North America output conform proportionately to changes in Inco's output, the smaller will be the impact of the data aggregation on the empirical results. Conversations with industry experts convinced us that conditions in North America were such that the impact would be small. Nonetheless, the potential bias introduced by the form of the available data should be noted.

The second difficulty involved econometric modeling. It was felt that the behavioral implications in equation (4) might be inadequate to explain the behavior of firms [country groups] operating in an extractive industry like the nickel industry. Of particular concern was the depletable nature

of the cost function and the significant adjustment costs apparent in this sector. Hence, to obtain empirical results, equation (4) was modified. The discussion to follow describes these modifications and the empirical results associated with each.

Model 1

While equation (4) is capable of reflecting the differences in the behavior of the dominant firm and the competitive fringe as described earlier, it does not reflect the fact that, in an extractive industry, the firm's cost of production [extraction] in period t depends on the amounts extracted in preceding periods.[4] A depletable cost function for firm i in period t would take the form[5]

$$C_t^i = f(q_{t-1}^i, q_{t-2}^i, \ldots) \tag{5}$$

Alternatively, since costs in period t are determined by previous extraction, equation (5) implies that cost in period t can be expressed as a function of the total deposit remaining. So, equation (5) can be rewritten as

$$C_t^i = f(TD - \sum_{k=0}^{t-1} q_k^i) \tag{6}$$

where TD represents the total deposit -- an unknown, but constant, stock.[6] Continuing to use the linear specification, we express (6) as

$$C_t^i = \beta_0 + \beta_1 TD + \beta_2 \sum_{k=0}^{t-1} q_k^i \tag{7}$$

where $\beta_1 < 0$ and $\beta_2 > 0$.

In addition to the depletable cost function, costly adjustment may present a specification problem: firms in an extractive industry can not easily adjust to major changes in price and demand conditions over extended periods.[7] Hence, we posit that the firm makes production <u>plans</u> based on its <u>expectations</u> concerning price and demand. Using this concept, planned output for the competitive firm will be determined by price expectations, and equation (1) is modified as

$$q^* = f\,(p^e,\ C), \tag{1'}$$

where p^e represents expected price. Likewise, planned output for the dominant firm is determined by expected market demand; so equation (2) becomes

$$q^* = f[(D^e - Q^f),\ C] \tag{2'}$$

Incorporating the characteristics noted above into equation (4), the basic equation can be rewritten in terms of <u>planned</u> production as

$$\begin{aligned}(q_t^i)^* = {} & [\alpha_0 + \alpha_4\beta_0 + \alpha_4\beta_1 TD] + \alpha_1 p_t^e + \alpha_2 D_t^e \\ & + \alpha_3 \sum^{j\neq i} q_t^j + \alpha_4\beta_2 \sum_{k=0}^{t-1} q_k^i\end{aligned} \tag{8}$$

Clearly, to obtain an estimating equation from (8), it would be necessary to specify (i) the manner in which price and demand expectations are formed and (ii) the relation between planned and actual production.

Consider first the formation of price expectations. In another paper the author used a rational expectations framework to describe the formation of price expectations, defining price expectations to be determined by the historical trend in price and by the change in the world inventory of the commodity:[8]

$$p_t^e = \frac{\gamma_1}{1-\lambda L} p_{t-1} + \gamma_2(S_{t-1} - D_{t-1}) \tag{9}$$

where S represents world production (i.e., $\sum_j Q^j$), L is a one-period lag operator, $\gamma_1 > 0$, and $\gamma_2 < 0$. However, note that it is only the competitive fringe for whom these price expectations are relevant. (For the dominant firm, $\alpha_1 = 0$ in (8).) Received theory of the behavior of firms in a market characterized by dominant firm price leadership does not suggest that the firms in the competitive fringe observe world market conditions, i.e., for the competitive fringe, $\gamma_2 = 0$. Hence, a simpler autoregressive framework would provide the same analytic results,

$$p_t^e = \frac{\gamma}{1-\lambda L} p_{t-1} \tag{9'}$$

An autoregressive framework is also used for expected world demand (total), i.e.,

$$D_t^e = \frac{\theta}{1-\lambda L} D_{t-1} \tag{10}$$

where $\theta > 0$.

We posit that firms in an extractive industry form production plans on the basis of their expectations about price or demand. However, the model must permit the firm some latitude to adjust production levels if expectations are not realized. Hence, the relation between actual production (q_t^i) and planned production $(q_t^i)^*$ is specified as

$$q_t^i - (q_t^i)^* = \delta_1(p_t - p_t^e) + \delta_2(D_t - D_t^e) \tag{11}$$

where $0 \leq \delta_1$ and $\delta_2 < 1$.

Incorporating (9'), (10), and (11) into (8), the estimating equation is obtained:

$$\begin{aligned} q_t^i = {} & \phi_0 + \phi_1 p_t + \phi_2 p_{t-1} + \phi_3 D_t + \phi_4 D_{t-1} \\ & + \phi_5 W_t + \phi_6 W_{t-1} + \phi_7 CP_{t-2}^i + \phi_8 q_{t-1} \end{aligned} \tag{12}$$

where $W = \sum^{j \neq i} q^j$ and $CP_{t-2} = \sum^{t-2} q_k^i$. The parameters in (12) can be related to the underlying parameters as

$$\begin{aligned} \phi_0 &= [\alpha_0 + \alpha_4\beta_0 + \alpha_4\beta_1 TD](1 - \lambda) \\ \phi_1 &= \delta_1 & \phi_5 &= \alpha_3 \\ \phi_2 &= \alpha_1\gamma - \delta_1(\gamma + \lambda) & \phi_6 &= -\alpha_3\lambda \\ \phi_3 &= \delta_2 & \phi_7 &= \alpha_4\beta_2(1 - \lambda) \\ \phi_4 &= \alpha_2\theta - \delta_2(\theta + \lambda) & \phi_8 &= \alpha_4\beta_2 + \lambda \end{aligned}$$

Predictions of the signs of these parameters for the dominant firms and for the competitive fringe firms are presented in Table 1. Note that the sign predictions for ϕ_7 and ϕ_8 do not depend on whether firm i is the dominant firm. However, for the firms in the competitive fringe, $\phi_3 = \phi_4 = \phi_5 = \phi_6 = 0$, and for the dominant firm, $\phi_1 = \phi_2 = 0$. Hence, with respect to the paradigm of dominant firm price leadership, we have two null hypotheses:

$$H_1^0 : \phi_3 = \phi_4 = \phi_5 = \phi_6 = 0$$
$$H_2^0 : \phi_1 = \phi_2 = 0$$

If the market is characterized by dominant firm price leadership, tests of these null hypotheses should proceed as follows:

For the dominant firm,

Reject H_1^0 Do Not Reject H_2^0

For firms in the competitive fringe,

Do Not Reject H_1^0 Reject H_2^0

While the principal hypothesis of this paper is that the nickel market was characterized by dominant firm price leadership, we must consider alternative behavioral paradigms.

TABLE 1
Sign Predictions for Parameters of Equation (12)

	Dominant Firm	Competitive Fringe
ϕ_1	$= 0$	≤ 0
ϕ_2	$= 0$	?
ϕ_3	≥ 0	$= 0$
ϕ_4	?	$= 0$
ϕ_5	< 0	$= 0$
ϕ_6	> 0	$= 0$
ϕ_7	< 0	< 0
ϕ_8	?	?

In this paper two alternatives will be examined: (1) a structure based on Cournot or von Stackelburg oligopoly and (2) a competitive structure.

Under a structure characterized by either Cournot or Von Stackelburg oligopoly, a firm's output decision is based on the output of its rivals; i.e., the reaction function. Furthermore, since each firm possesses a degree of market power, total market demand rather than price will be relevant. Hence, for any of the firms, the output decision could be modeled as

$$q_t^i = f(D_t, \sum^{j \neq i} q_t^j, C_t^i) \tag{13}$$

Compare this function to equation (3). Under the market structure described by (13), the parameters of equation (12) for <u>all firms</u> would be as specified for the dominant firm. That is, if the nickel market is characterized by oligopoly, the tests of null hypotheses H_1^0 and H_2^0 for all firms should be

Reject H_1^0 Do Not Reject H_2^0

Alternatively, under a competitive system, all firms would base their output decisions on price and marginal cost. Continuing to use our concept of planned production and expected price, this means that planned production for all firms in the market would be determined by

$$(p_t^i)^* = f(p_t^e, C_t^i) \tag{14}$$

If price expectations are formed autoregressively (as posited previously); it follows that the predicted signs for the coefficients for all firms are precisely those given for the competitive fringe firms in the preceding.

This is, for all firms , tests of null hypotheses H_1^0 and H_2^0 should result in

Do Not Reject H_1^0 Reject H_2^0

On the other hand, price expectations in a competitive market could follow a rational expectations formulation,

$$p_t^e = \frac{\gamma_1}{1-\lambda L} p_{t-1} + \frac{\gamma_2}{1-\lambda L} (S_{t-1} - D_{t-1}) \tag{15}$$

Combining (15) with (14) and using a linear functional form, we obtain an estimation equation of the form

$$\begin{aligned} q_t^i = {} & \phi_0 + \phi_1 p_t + \phi_2 p_{t-1} - (\alpha_1 - \delta_1)\gamma_2 D_{t-1} \\ & + (\alpha_1 - \delta_1)\ \gamma_2\ W_{t-1} \\ & + \phi_7\ \ CP_{t-2} \\ & + [\phi_8 + (\alpha_1 - \beta_1)\ \gamma_2]\ q_{t-1}^i \end{aligned} \tag{16}$$

In terms of equation (12), equation (16) implies that <u>for all firms</u>, the parameters for D_t and W_t are zero,

$$\phi_3 = \phi_5 = 0,$$

and the parameters for D_{t-1} and W_{t-1} are identical,

$$\phi_4 = -\phi_6$$

Thus, in the case of a competitive market in which expectations are formed via rational expectations, there exists a third null hypothesis:

$$H_3^0: \phi_3 - \phi_5 - 0 \text{ and } \phi_4 - -\phi_6$$

if the nickel market was characterized by competition with rational expectations, H_3^0 would not be rejected for any firm [country group].

The predictions about whether or not the three null hypotheses will be rejected under

- dominant firm price leadership,
- oligopoly,
- competition with autoregressive expectations, and
- competition with rational expectations

are summarized in Table 2. Treating the country groups as firms, North America is posited to be the dominant firm; South America, Asia, Africa, Europe, Oceania, and the centrally planned economies are posited to be competitive fringe firms.

To test the hypotheses, equation (12) was estimated for each country group using data for the period 1950-1980.[9] The results of these estimations are displayed in Table 3. A variable DUMMY is included in equations for South America and Centrally Planned Economies to relfect the fact that, after 1962, production from Cuba was included in the figures for the Centrally Planned Economies.

TABLE 2
Tests For Alternative Market Structures

		NA	SA	AS	AF	EU	OC	CP
(1)	H_1^0	R	•	•	•	•	•	•
	H_2^0	•	R	R	R	R	R	R
(2)	H_1^0	R	R	R	R	R	R	R
	H_2^0	•	•	•	•	•	•	•
(3)	H_1^0	•	•	•	•	•	•	•
	H_2^0	R	R	R	R	R	R	R
(4)	H_2^0	R	R	R	R	R	R	R
	H_3^0	•	•	•	•	•	•	•

(1) Dominant frim price leadership
(2) Oligopoly
(3) Competition with autoregressive expectations
(4) Competition with rational expectations

TABLE 3
Parameter Estimates of Equation (12)
T-Statistics in Parentheses)

	NA	SA	AS	AF	EU	OC	CP
CONSTANT	-164.054 (-2.408)	-41.268 (-4.285)	-2.406 (-0.362)	-2.980 (-0.536)	-2.626 (-0.637)	-61.037 (-1.622)	48.714 (4.053)
P_t	2.329 (2.014)	0.453 (2.607)	-0.003 (0.020)	0.004 (0.035)	0.029 (0.400)	1.302 (2.220)	0.206 (1.144)
P_{t-1}	1.169 (0.905)	-0.082 (-0.435)	0.059 (0.444)	-0.007 (-0.065)	-0.027 (-0.371)	-0.936 (-1.546)	-0.324 (1.858)
D_t	0.159 (0.750)	0.079 (3.429)	-0.030 (-1.617)	0.060 (3.187)	0.026 (2.862)	-0.011 (-0.146)	0.022 (0.780)
D_{t-1}	0.344 (1.647)	0.031 (1.001)	0.013 (0.592)	-0.066 (-3.094)	-0.018 (-1.429)	0.048 (0.446)	-0.003 (-0.091)
W_t	0.202 (0.512)	-0.061 (-2.424)	0.014 (0.593)	0.011 (0.607)	-0.005 (0.395)	0.125 (1.118)	0.004 (0.169)
W_{t-1}	-0.843 (-1.951)	-0.005 (-0.200)	-0.004 (-0.224)	0.003 (0.197)	0.007 (0.650)	0.047 (0.392)	0.060 (2.120)
CP_{t-2}	-0.019 (-0.515)	-0.056 (-2.136)	0.183 (2.307)	-0.002 (-0.052)	-0.014 (-0.789)	-0.008 (-0.621)	0.012 (2.509)
Q_{t-1}	0.274 (1.407)	0.623 (5.234)	0.631 (2.106)	1.031 (4.204)	0.865 (4.787)	0.527 (2.452)	0.382 (3.458)
DUMMY		15.158 (3.345)					-30.083 (-6.550)
R^2	0.813	0.902	0.978	0.986	0.965	0.966	0.996

TABLE 4
Hypothesis Tests
(Marginal Significance Levels in Parentheses)

	NA	SA	AS	AF	EU	OC	CP
H_1^0	4.377 (0.010)	4.910 (0.006)	0.746 (0.572)	3.972 (0.015)	2.477 (0.075)	2.146 (0.111)	1.677 (0.195)
H_2^0	5.481 (0.012)	3.865 (0.038)	0.121 (0.887)	0.002 (0.998)	0.105 (0.901)	2.794 (0.084)	1.780 (0.194)
H_3^0	1.149 (0.352)	5.234 (0.008)	0.935 (0.441)	5.288 (0.007)	3.178 (0.045)	1.986 (0.147)	1.840 (0.172)

The tests of hypotheses H_1^0, H_2^0, and H_3^0, all entail an F test. Table 4 contains the calculated F-values for each of three tests for each of the seven country groups. In addition, Table 4 indicates the marginal significant level for rejecting the null hypothesis. (for example for North America, H_1^0 could be rejected at a significance level of 1% -- or a confidence level of 99%, while rejection of H_3^0 for Oceania would have a significance level of 14.7%.)

To make comparison with Table 2 easier, the result contained in Table 4 are further summarized in Table 5. This table indicates (far too clearly) that the empirical results for Model 1 fail to support <u>any</u> market structure. Even eliminating Asia and the centrally planned economies, for which none of the market structures are rejected, and South America, for which all of the market structures are rejected, no discernable pattern is evident. Indeed, on the basis of these empirical results only, the country groups (again excepting Asia, centrally planned, and South America) would be characterized as follows

North America - Competitive with rational expectations formation

Africa - Oligopoly

Europe - Oligopoly

Oceania - Competitive

TABLE 5
Empiral Results for Tests for Alternative Market Structure

	NA	SA	AS	AF	EU	OC	CP
H_0^1	RRR	RRR	•	RR	R	•	•
H_0^2	RR	RR	•	•	•	R	•
H_0^3	•	RR	•	RRR	RR	•	•

RRR - Reject H_0 at 1% significance level
RR - Reject H_0 at 5% significance level
R - Reject H_0 at 10% significance level

Model 2

In Model 1, we emphasized two features of an extractive industry: the depletable cost function and the cost of adjusting production. The latter led us to incorporate the formation of expectations about price or about demand (to reconcile planned and actual production). Given the disappointing results from Model 1, in conjunction with the ad hoc manner in which expectation formation was specified, we developed an alternative model which reflects the depletable cost function but eliminates all of the expectational aspects of decision making.

We began with a (world) market demand curve,

$$D_t = f(p_t, X_t), \tag{17}$$

where X represents all variables capable of shifting the demand curve. Using a linear specification,

$$D_t = \alpha_0 - \alpha_1 p_t + \alpha_2 X_t. \tag{18}$$

Define the marginal cost function of the i-th firm as

$$MC_t^i = -(\beta_{0i}/\beta_{1i}) + (1/\beta_{1i})\, q_t^i - (\beta_{2i}/\beta_{1i}) Z_t^i \tag{19}$$

where Z is a vector of variables including not only past production (to provide the depletable cost function) but also other variables which would be expected to shift the marginal cost function.

A competitive firm -- either in a competitive market or as part of the competitive fringe in dominant firm price leadership -- will produce at that output at which $p_t = MC_t^i$. Using equation (19), thus implies a competitive supply function of the form

$$q_t^i = \beta_{0i} + \beta_{1i} p_t + \beta_{2i} Z_t^i \tag{20}$$

If the market is characterized by dominant firm price leadership, the output decision of the dominant firm is not characterized by (20) but is instead determined by the intersection of its own marginal cost curve and the marginal revenue curve associated with the residual demand curve. Using (18)

and (20), we can express this residual demand -- the demand curve facing the dominant firm -- as

$$\begin{aligned} d_t^i &= D_t - \sum^{j \neq i} q_t^i \\ &= (\alpha_0 - \sum^{j \neq i} \beta_{0j}) - (\alpha_1 + \sum^{j \neq i} \beta_{1j})\, p_t + \alpha_2 X_t - \sum^{j \neq i} \beta_{2j} Z_t^j \\ &= \gamma_{0i} - \gamma_{1i} p_t + \gamma_{2i} W_t^i \end{aligned} \tag{21}$$

where

$$\gamma_{0i} = \alpha_0 - \sum^{j \neq i} \beta_{0j},$$

$$\gamma_{1i} = (\alpha_1 + \sum^{j \neq i} \beta_{1j})\, p_t, \text{ and}$$

$$\gamma_{2i} W_t^i = \alpha_2 X_t - \sum^{j \neq i} \beta_{2j} Z_t^j.$$

The marginal revenue curve associated with (21) is

$$MR_t^i = \frac{1}{\gamma_{1i}} [\gamma_{0i} - 2d_t^i + \gamma_{2i} W_t^i]. \tag{22}$$

Equating marginal revenue and marginal cost in the form of equations (22) and (19), then replacing d_t^i with q_t^i, the output function for the dominant firm is

$$q_t^i = \delta_{0i} + \delta_{1i}X_t + \delta_{2i}Z_t^i - \delta_{3i}\sum_{j\neq i}\beta_{2j}Z_t^j, \qquad (23)$$

where

$$\delta_{0i} = (\beta_{0i}\gamma_{1i} + \beta_{1i}\gamma_{0i}) / (\gamma_{ii} + 2\beta_{1i}),$$
$$\delta_{1i} = \gamma_2\beta_{1i} / (\gamma_{1i} + 2\beta_{1i}),$$
$$\delta_{2i} = \beta_{2i}\gamma_{1i} / (\gamma_{1i} + 2\beta_{1i}), \text{ and}$$
$$\delta_{3i} = \beta_{1i} / (\gamma_{1i} + 2\beta_{1i}).$$

Hence, we have output functions for competitive firms, equation (20), and the dominant firm, equation (23). However, to make these functions estimable, it is necessary to specify the demand-shift variables, X, and the variables that impact on marginal cost, Z. As variables capable of shifting the (world) market demand function, we include the lagged response of market demand (D_{t-1} and p_{t-1}) and the current level of GNP (Y_t). For the marginal cost function, we include not only cumulative past production ($CP_{t-2}^i = \sum_{k=0}^{t-2} q_k^i$) but also q_{t-1}^i and p_{t-1}. Cumulative past production provides the depletable cost function, while lagged output and price capture the effects of changes due to capacity and utilization effects.

Incorporating the preceding into equation (23), the resulting output function for the dominant firm could be expressed in implicit functional form as

$$q_t^i = f(p_{t-1}, D_{t-1}, CP_{t-2}^i, q_{t-1}^i, Y_t, \sum^{j \neq i} (\theta_{1j} q_{t-1}^j + \theta_{2j} p_{t-1} + \theta_{3j} CP_{t-2}^j)) \quad (24)$$

Equation (24) contains too many variables to be used as a regression equation. (With seven country groups, equation (24) would contain 17 variables.) To make this equation manageable, we must make a simplifying assumption:

> The dominant firm behaves as if the cost functions for the firms in the competitive fringe are identical. That is, $\theta_{1j} = \theta_1$, $\theta_{2j} = \theta_2$, and $\theta_{3j} = \theta_3$.

Using this assumption and incorporating the behavioral paradigm that the dominant firm reacts to residual demand ($d = D - W$), an estimation equation corresponding to (24) may be written as

$$\begin{aligned} q_t^i = {} & \phi_0 + \phi_2 p_{t-1} + \phi_3 (D_{t-1} - W_{t-1}) \\ & + \phi_4 CP_{t-2}^i + \phi_5 \sum^{i \neq j} CP_{t-2}^j \\ & + \phi_6 Y_t + \phi_7 q_{t-1}^i \end{aligned} \quad (25)$$

Incorporating CP_{t-2}^i, q_{t-1}^i, and p_{t-1} into equation (20), the output function for a competitive firm becomes

$$q_t^i = \phi_0 + \phi_1 p_t + \phi_2 p_{t-1} + \phi_4 CP_{t-2}^i + \phi_7 q_{t-1}^i \quad (26)$$

Then, combining (25) and (26), the estimation equation for Model 2 is

$$q_t^i = \phi_0 + \phi_1 P_t + \phi_2 P_{t-1} + \phi_3 (D_{t-1} - W_{t-1}) + \phi_4 CP_{t-2}^i + \phi_5 \sum_{i \neq j} CP_{t-2}^j + \phi_6 Y_t + \phi_7 q_{t-1}^i. \quad (27)$$

The predicted signs for the parameters of (27) for the dominant firm and for firms in the competitive fringe are summarized in Table 6.

TABLE 6
Sign Predictions for Parameters of Equation (27)

	Dominant Firm	Competitive Fringe
ϕ_1	0	>0
ϕ_2	?	?
ϕ_3	>0	0
ϕ_4	<0	<0
ϕ_5	>0	0
ϕ_6	>0	0
ϕ_7	>0	>0

The signs of parameters ϕ_2, ϕ_4, and ϕ_7 are invariant; it is parameters ϕ_1, ϕ_3, ϕ_5, and ϕ_6 that reflect the behaviorial differences. If firm i is the dominant firm, $\phi_1 = 0$. Alternatively, if the firm is part of the competitive fringe, $\phi_3 = \phi_5 = \phi_6 = 0$. Hence, for equation (27), we have two null hypotheses

$$H_1^0: \quad \phi_3 = \phi_5 = \phi_6 = 0$$
$$H_2^0: \quad \phi_1 = 0$$

As was the case with Model 1, these two null hypotheses can be used to determine if the market is more aptly characterized by (i) dominant firm price leadership, (ii) oligopoly, or (iii) competition. The predictions for each of these market structures are summarized in Table 7. In essence, the tests are the same employed for Model 1.

The results of the estimation of equation (27), including the F-test of null hypothesis H_1^0 are presented in Table 8. And, to make the comparison with Table 7 easier, the results of the F-tests of H_1^0 and the t-tests of H_2^0 are summarized in Table 9.

TABLE 7
Tests for Alternative Market Structures

		NA	SA	AS	AF	EU	OC	CP
(1)	H_1^0	R	•	•	•	•	•	•
	H_2^0	•	R	R	R	R	R	R
(2)	H_1^0	R	R	R	R	R	R	R
	H_2^0	•	•	•	•	•	•	•
(3)	H_1^0	•	•	•	•	•	•	•
	H_2^0	R	R	R	R	R	R	R

(1) Dominant firm price leadership
(2) Oligopoly
(3) Competition

TABLE 8
Parameter Estimates of Equation (27)

	NA	SA	AS	AF	EU	OC	CP
CONSTANT	428.774 (1.482)	-96.695 (-2.229)	23.346 (0.633)	-21.354 (-0.508)	-28.042 (-1.222)	-18.519 (-0.106)	17.891 (0.386)
P_t	1.383 (1.571)	0.153 (1.071)	0.055 (0.461)	0.055 (0.488)	-0.002 (-0.021)	1.501 (2.593)	0.501 (1.950)
$(D_{t-1} - W_{t-1})$	0.350 (1.823)	0.020 (0.730)	0.004 (0.190)	0.001 (-0.038)	-0.007 (-0.617)	0.095 (0.925)	-0.036 (-1.403)
Y_t	-917.237 (-1.686)	155.809 (1.699)	-58.774 (-0.801)	25.239 (0.291)	57.216 (1.260)	-85.062 (-0.242)	61.720 (0.619)
$\Sigma\ CP_{t-2}$	-0.173 (-0.891)	-0.036 ((-1.113)	0.021 (0.682)	-0.010 (-0.278)	-0.019 (-0.910)	0.084 (0.462)	0.018 (0.310)
P_{t-1}	0.894 (0.768)	-0.144 (-0.615)	0.079 (0.548)	0.055 (0.332)	-0.056 (-0.645)	-0.554 (-0.769)	-0.293 (-1.444)
Q_{t-1}	-0.095 (-0.467)	0.588 (3.953)	0.570 (1.872)	0.489 (1.613)	0.855 (4.453)	0.598 (2.721)	0.441 (3.572)
CP_{t-2}	0.143 (2.212)	-0.077 (-2.281)	0.179 (1.637)	0.089 (1.838)	-0.007 (-0.192)	-0.026 (-1.055)	-0.006 (-0.287)
DUMMY		15.217 (3.641)					-30.959 (-6.113)
R^2	0.841	0.883	0.976	0.975	0.985	0.957	0.995
Hypothesis Tests (Marginal Significance Level in Parentheses)							
H_1	8.495 (0.001)	4.579 (0.013)	0.366 (0.778,	0.033 (0.992)	1.515 (0.239)	0.991 (0.415)	1.012 (0.407)

TABLE 9
Empirical Results for Tests for Alternative Market Structures

	NA	SA	AS	AF	EU	OC	CP
H_1^0	RRR	RR	•	•	•	•	•
H_2^0	•	•	•	•	•	R	R

RRR - Reject H_0 at the 1% significance level
RR - Reject H_0 at the 5% significance level
R - Reject H_0 at the 10% significane level

While not overwhelming, these results are supportive of dominant firm price leadership: For the country group containing the posited dominant firm, we were able to reject competitive behavior in favor of dominant firm behavior. For those country groups containing the bulk of remaining world production -- Oceania (Australia and New Caledonia) and the centrally planned economies (the Soviet Union) -- dominant firm behavior is rejected in favor of competitive behavior. It is with respect to the country groups having minor shares of world production that the empirical results fail to be as predicted. In the case of Asia, Africa, and Europe we were able to reject neither type of behavior. However, given the levels of production forthcoming from each of these country groups, such a result is not unexpected. The most surprising result was for South America: competitive behavior was rejected in favor of dominant firm behavior. For this result, we have no ready explanation. Instead, this result is one requiring additional research. Nonetheless, the overall results from Model 2 do provide some empirical support for the nation of dominant firm price leadership. Comparing Table 9 with Table 7, the empirical results conform

much more to dominant firm price leadership than to either a form of oligopoly behavior or competitive behavior.

Concluding Remarks

In this paper we have tried to put together two widely held beliefs:

(1) The belief that a market characterized by one large firm and a number of smaller firms would follow a behavioral paradigm such that the dominant firm would set price so as to maximize its own profit while permitting the smaller firms to sell as much as they desired at the price set and

(2) the belief that the world nickel market was characterized by dominant firm price leadership, at least until the 1970s.

Put another way, we used the data from the nickel market to examine empirically the theory of dominant firm price leadership.

We constructed two models to examine the behavior of participants in the world nickel market. In the first, we explicitly incorporated the depletable cost function and the dynamic adjustment of this market, via expectations. In the second, we eliminated the expectational aspects, while maintaining the depletable cost function.

These empirical models were estimated using the available data for the world nickel market for the period 1950-1980. A limitation in these data

was that it was available only by country group; so, the empirical analysis was in terms of a dominant/competitive fringe country group rather that firm. Data limitations notwithstanding, the estimates from the first model were most unsatisfactory: we were unable to indicate that the behavior was generated by either dominant firm price leadership, oligopoly, or competition. The estimates from the second model were considerably more satisfactory. While not overwhelming, these results conformed to the predictions forthcoming from a model of dominant firm price leadership. Indeed, looking at the estimates from the second model, it was clear that the observed market behavior was much more likely to have been the result of dominant firm price leadership than of either an oligopoly structure or a competitive market.

Hence, we end with results that are suggestive but not conclusive. As such, they are similar to the results of Maurice and Mizzi (1984) when they found that the behavior of the nickel market was consistent with that predicted by a market characterized by dominant firm price leadership with a capital adjustment constraint.

FOOTNOTES

* Both of Texas A&M University. C.W. Smithson is currently on leave of absence.

[1] See Griffin (1985) for the test of various market structures in oil industry.

[2] Ontario Ministry of Natural Resources Mineral Policy Background Paper No. 21, July 1984.

[3] See Smithson, Anders, Hwang and Martin (1981).

[4] Much of the modeling used in the analysis is based on earlier econometric work by the authors in collaboration with other researchers. In particular, see C.W. Smithson, G. Anders, W.P. Gramm, and S.C. Maurice, World Mineral Markets: An Econometric and Simulation Analysis (Ontario Ministry of Natural Resources Background Paper No. 8) and C.W. Smithson, G. Anders, Hae Shin Hwang, and R.D. Martin world Mineral Markets, Stage II: An Econometric and Simulation Approach to the World Markets for Copper, Aluminum, Nickel, and Zinc (Ontario Ministry of Natural Resources Background Paper No. 14)

[5] For additional discussion on the depletable cost function, see Gerhard Anders, W. Philip Gramm, S. Charles Maurice, and Charles W. Smithson, The Economics of Mineral Extraction (New York: Pareger, 1980).

[6] This approach will not however require that the amount of the total deposit is known with certainty. We also must remember that only a (meaningless) physical "stock" is constant. The economic value of the stock is quite changeable.

[7] Indeed, it is with this issue that a significant portion of the work by Maurice and Mizzi (1984) dealt.

[8] Smithson, Anders, Hwang, and Martin

[9] The data used and descriptions of the manner in which the variables were constructed can be found in the appendix to this paper.

REFERENCES

Anders, G., W.P. Gramm, S.C. Maurice and C.W. Smithson: The Economics of Mineral Extraction, New York (Praeger, 1980).

Griffin, J.M.: "Opec Behavior: A Test of Alternative Hypotheses," American Economic Review, December 1985, 954-963.

Hwang, H. and C.W. Smithson: "An Empirical Approach to Markets for Non-renewable Resources," in Mineral Policy Background Paper 22, Ontario Ministry of Natural Resources, March 1985.

Maurice, S.C. and C.W. Smithson: Managerial Economics, Homewood, Illinois, Richard D. Irwin, 1981.

Maurice, S.C. and P.J. Mizzi: "An Analysis of Market Structure: The Nickel Industry," Mineral Policy Background Paper 21, Ontario Ministry of Natural Resources, March 1985.

Smithson, C.W., G. Anders, W.P. Gramm and S.C. Maurice: "World Mineral Markets - An Econometric and Simulation Analysis," Mineral Policy Background Paper 8, Ontario Ministry of Natural Resources, May 1979.

Smithson, C.W., G. Anders, H.Hwang and D. Martin: "World Mineral Markets Stage II - An Econometric and Simulation Approach to the World Markets for Copper, Aluminum, Nickel and Zinc," Mineral Policy Background Paper 14, Ontario Ministry of Natural Resources, September 1981.

United Nations, Statistical Yearbook, New York.

APPENDIX

The source of data used in this study is described in Smithson, Anders, Hwang and Martin (1981). The primary production by country group is updated and is presented in Table A.1. Data for the consumption of refined nickel is also updated and the total consumption of all country groups is reported in Table A.2 as world demand. The price is the real price, nominal price deflated by the U.S. wholesale price index. The income data in table A.2 is the average of the per capita gross domestic products of seven country groups.

TABLE A.1

PRIMARY PRODUCTION (THOUSANDS OF METRIC TONS)

YEAR	NORTH AMERICA	SOUTH AMERICA	ASIA	AFRICA	EUROPE	OCEANIA	CENTRALLY PLANNED
1947	107.6	2.6	0.0	0.6	0.5	2.9	16.2
1948	119.5	0.8	0.0	0.6	0.2	3.6	17.8
1949	116.7	0.7	0.0	0.6	0.1	2.5	25.4
1950	112.2	0.8	0.0	0.9	0.4	4.3	29.6
1951	125.1	0.7	0.6	1.2	0.1	6.7	33.7
1952	127.5	8.7	0.1	1.5	0.4	10.7	37.8
1953	131.0	12.7	0.1	1.8	0.2	17.1	41.0
1954	146.7	13.2	0.1	2.0	0.1	13.7	43.0
1955	162.2	13.9	0.2	2.0	0.1	24.7	45.1
1956	168.0	14.7	0.1	3.5	0.8	29.5	48.5
1957	179.6	20.3	0.1	3.4	1.1	43.3	51.6
1958	137.3	18.0	0.4	1.4	0.4	14.2	54.9
1959	179.7	17.9	0.1	2.8	0.3	32.8	55.0
1960	206.0	14.6	0.2	3.2	2.1	53.0	60.3
1961	221.5	16.6	0.5	2.9	2.0	54.0	62.8
1962	225.2	20.1	0.5	3.8	2.4	34.5	65.0
1963	207.3	1.0	1.1	3.6	2.9	44.5	102.7
1964	218.4	1.1	1.2	4.6	3.2	58.2	105.3
1965	247.4	1.1	2.4	6.3	3.0	61.2	110.2
1966	214.9	1.1	2.6	6.5	3.0	67.8	119.7
1967	338.9	1.1	3.9	6.9	5.9	84.8	134.5
1968	253.5	1.1	5.7	9.0	7.4	120.8	147.6
1969	208.1	1.3	5.0	15.0	9.2	128.0	147.5
1970	291.6	3.0	10.9	20.3	13.6	168.3	155.5
1971	281.2	3.5	15.0	22.3	14.6	186.4	155.8
1972	249.2	20.8	14.5	22.0	17.0	143.6	156.2
1973	261.6	34.2	16.3	31.1	20.3	156.0	154.6
1974	281.9	34.0	16.4	42.8	21.8	182.9	163.4
1975	255.2	30.1	24.2	36.5	20.9	209.3	172.9
1976	252.7	29.8	29.1	49.7	23.2	202.2	178.0
1977	245.1	29.0	52.9	50.6	15.9	202.7	183.4
1978	140.1	19.7	59.8	54.4	19.8	149.6	189.0
1979	138.6	34.3	69.2	61.0	21.0	152.6	191.2
1980	207.7	24.9	75.5	56.2	21.0	156.1	195.2

TABLE A.2

WORLD DEMAND, PRICE, INCOME

YEAR	WORLD DEMAND	REAL PRICE	INCOME
1947	122.1	45.752	
1948	134.9	44.123	
1949	119.5	50.826	
1950	157.1	54.758	0.53714
1951	154.4	59.276	0.56000
1952	174.1	63.770	0.56857
1953	182.3	68.522	0.58429
1954	181.2	69.010	0.60143
1955	206.9	74.601	0.62714
1956	230.9	71.847	0.64000
1957	235.3	79.314	0.65714
1958	195.4	78.224	0.67143
1959	247.8	78.059	0.68857
1960	290.5	77.977	0.71143
1961	307.8	82.172	0.73000
1962	300.3	84.277	0.75143
1963	342.8	83.598	0.77143
1964	397.8	83.421	0.81286
1965	428.6	81.442	0.83143
1966	467.6	79.058	0.86143
1967	473.0	87.774	0.88286
1968	490.4	92.683	0.93143
1969	502.8	98.983	0.96571
1970	576.6	116.834	1.00000
1971	526.6	116.769	1.03429
1972	560.1	117.269	1.07857
1973	639.5	113.586	1.13000
1974	692.7	108.057	1.16000
1975	559.2	118.544	1.16000
1976	648.3	123.087	1.22000
1977	624.7	123.680	1.27000
1978	681.0	99.904	1.32714
1979	757.9	115.238	1.37857
1980	707.2	127.093	

Ontario Ministry of Northern Development and Mines

Mineral Resources Branch

Mineral Policy Background Papers

No. 1: G. Anders, W. P. Gramm, S.C. Maurice: The Impact of Taxation and Environmental Controls on the Ontario Mining Industry - A Pilot Study, 1975. $ 3.00

No. 2: Staff, Metallic Minerals Section, Mineral Resources Branch: Towards an Iron Ore policy for the Province of Ontario, 1975. $ 2.00
(out of print)

No. 3: K. S. Rachamalla, D.H. Bell: Towards a Zinc Policy for the Province of Ontario, 5509(11/76) $12.00

No. 4: T. P. Mohide, C. L. Warden, J. D. Mason: Towards a Nickel Policy for the Province of Ontario. 5692(12/77) $25.00

No. 5: G. Anders, W. P. Gramm, S. C. Maurice, C. W. Smithson: Investment Effects on the Mineral Industry of Tax and Environmental Policy Changes: A Simulation Model. 5745(08/78) $ 5.00

No. 6: C. W. Smithson, G. Anders, W. P. Gramm, S. C. Maurice: Factor Substitution and Biased Technical Change in the Canadian Mining Industry. 5784(5/79) $ 5.00

No. 7: T. P. Mohide: The Platinum Group Metals - Ontario and the World. 5783(5/79) $25.00

No. 8: C. W. Smithson, G. Anders, W.P. Gramm, S.C. Maurice: World Mineral Markets - An Econometric and Simulation Analysis. 5785(5/79) $15.00

No. 9: P.B. Hildebrand, L.J. Frosch: Guide to Legislation Affecting Mining in Ontario. 5795(5/79) $15.00

No. 10: G. Anders, T. P. Mohide: The Future of Nickel and The Law of the Sea. 5824(2/80) $ 1.00

No. 10: G. Anders, T. P. Mohide: L'avenir du nickel et le droit de la mer. 5824(2/80) $ 1.00

No. 11: Centre for Resource Studies, Queen's University, and Staff, Metallic Minerals Section, Mineral Resources Branch: Ontario Mining Statistics, A Preliminary Compendium. 5833(04/80) $ 5.00

No. 12: T. P. Mohide: Gold. 5149(08/81) $30.00

No. 13: O.J.C. Runnalls: Ontario's Uranium Mining Industry - Past, Present and Future. 5085(07/81) $25.00

No. 14: C. W. Smithson, G. Anders, Hae Shin Hwang, R. D. Martin: World Mineral Markets - Stage II - An Econometric and Simulation Approach to the World Markets for Copper, Aluminum, Nickel and Zinc. 5248(09/81) $25.00

No. 15: C. W. Smithson, G. Anders, Hae Shin Hwang, L. F. Worley: World Mineral Markets - Stage III - A User Oriented Simulation Model of the World Markets for Copper, Aluminum, Nickel and Zinc. 5243(09/81) $30.00

No. 16: A.G. Green: Ontario's Metal Mining Statistics. 5329(1/83) $15.00

No. 17: C. W. Smithson & Associates: An Update of the Ontario Ministry of Natural Resources Model of the World Markets for Copper, Aluminum, Nickel and Zinc. 5368(09/83) $15.00

No. 18: J. D. Campbell, K. B. Snell: A Guide to Legislation Affecting Mining in Ontario. 5795(11/84) $20.00

No. 19: A. G. Green, M. A. Green: Productivity and Labour Costs in the Ontario Metal Mining Industry. 3271(04/85) $15.00

No. 20: T. P. Mohide: Silver 3213(01/85) $15.00

No. 21: S. C. Maurice, P. J. Mizzi: An Analysis of Market Structure. The Nickel Industry. 3272(04/85) $15.00

No. 22: Selected Papers on Mineral Economics Issues Affecting the Future of Ontario's Mineral Sector. 3273(04/85) $15.00

No. 23: Hae-Shin Hwang, Charles W. Smithson: Dominant Firm Price Leadership: An Emperical Examination. (11/86) $10.00

No. 24: Roscoe Postle Associates Inc: Review of Platinum Group Element Deposits in Ontario. (11/86) $15.00

Publications of the Mineral Resources Branch
and price list
are obtainable through the
Public Service Centre, Ontario Ministry of Natural Resources
99 Wellesley Street West, Toronto, Ontario, M7A 1W3

and

The Ontario Government Bookstore
880 Bay Street, Toronto, Ontario, M7A 1N8

Orders for publications should be accompanied by cheque
or money order, payable to the Treasurer of Ontario